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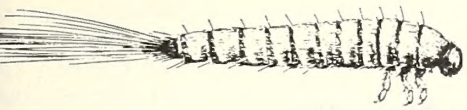

U.S. DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Marketing Research Division
Washington, D.C.

This report is part of a broad program of research designed to reduce the cost of marketing farm products, including the cost of preventing insect infestation in stored dairy products.

The work is the result of a cooperative effort between the Marketing Research Division, of the U. S. Department of Agriculture, and the Wisconsin Agricultural Experiment Station. Approved for publication by the Director of the Wisconsin Agricultural Experiment Station.

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Resistance of DRUMS AND BARRELS containing nonfat dry milk to INSECT INVASION

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SUMMARY

Drums and barrels of nonfat dry milk were stored in warehouse rooms heavily infested with the larger cabinet beetle, Trogoderma inclusum Lec., and the black carpet beetle, Attagenus piceus (Oliv.), the two species most frequently encountered in dry milk plants and warehouses, to determine the resistance of the containers to insect invasion. The milk was packaged according to present commercial practice for sale under the Government price-support purchase program. The individual resistance of each barrier element, such as the container itself, the outer kraft liner, the inner polyethylene liner, and the kraft sealer, was evaluated either by eliminating the others or by placing insects between them. The value of insecticidal treatments was studied by the same method. Empty drums and packages of liners were also exposed in the rooms to determine whether the insects would use them for harborage.

Both species of insects demonstrated their ability to invade either type of container, with or without sealers, and to penetrate each type of liner, but when all of the barriers were combined, the insects did not pass all of them and infest the milk itself. It was indicated that malathion may be useful as an additional barrier. A few insects also used the empty drums and packages of liners for harborage.

It was concluded that the standard method of packing dry milk in drums using a kraft sealer, an outer kraft liner, and an inner polyethylene liner results in a package highly resistant to invasion by the larger cabinet beetle and the black carpet beetle during storage.

INTRODUCTION

The resistance to insect invasion of fiberboard drums and wooden barrels in which nonfat dry milk is packed for storage under the Government price-support purchase program is of considerable concern to both the Commodity Credit Corporation (CCC) and the producers of the milk. If the drums and barrels are tight enough to prevent invasion by species of dermestid beetles, any infestation found in stored dry milk must originate before or at the time of packaging, and the producer must concentrate on measures at the plant to prevent this occurrence. If, on the contrary, the barrels and drums are readily invaded by the insects, measures to improve the containers or control the sources of infestation in the warehouse are needed.

Experiments were conducted at Madison, Wis., during the period 1955 to 1957 to study the resistance of the containers to insect invasion and to explore the possibilities of treating the containers with insecticides to improve their resistance if such were necessary. These experiments were made in cooperation with the Livestock and Dairy Division, Commodity Stabilization Service.

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[1] This laboratory is a field station of the Stored-Product Insects Section, Biological Sciences Branch, Marketing Research Division, Agricultural Marketing Service, U. S. Department of Agriculture. J. E. Gorman, of this laboratory, assisted in these tests.

TEST ROOMS AND MATERIALS

Two series of tests were conducted in which drums and barrels of nonfat dry milk were stored in heavily infested rooms. In each instance 2 rooms 250 to 300 square feet in area were used, one infested with the larger cabinet beetle, Trogoderma inclusum Lec., and the other with the black carpet beetle, Attagenus piceus (Oliv.). In the first series the rooms were heated during the winter months by a steam radiator; the temperatures ranged from 64° to 90° F., and the relative humidity from 24 to 92 percent. In the second series the rooms were unheated and the temperatures ranged from 37° to 88° and the relative humidity from 38 to 80 percent.

The drums in the first series were of fiberboard, the type most commonly used in industry, and contained 225 pounds of milk. After filling, the drums were covered with a metal lid that was securely fastened to the drum by a metal band tightened by means of a lever. The barrels were of standard wooden construction. In the second series, drums of similar construction were used, but they were only one-fourth the capacity of the standard. If liners were used in the drums and barrels, these consisted of an outer one constructed from crinkled kraft paper and an inner one from 2-mil polyethylene. Both liners were in the form of bags and were tied shut with string after filling. A circular kraft sealer was also used under each metal lid in most of the drums.

The milk for the first series of tests was obtained from a single milk-drying plant shown by inspection to be free of insects. The same milk was used in the second series after being resifted and thoroughly inspected to insure freedom from infestation.

In the second series of tests 2 insecticidal sprays were used. One contained pyrethrins and piperonyl butoxide in a 1 to 10 ratio diluted to a concentration of 0.1 percent pyrethrins. The other contained 1 percent of malathion. The sprays were applied at the rate of 4 cubic centimeters per square foot to the exterior of some of the filled drums and to the inner surface of some of the open, empty ones.

PROCEDURE

The first series of tests was set up during August 1955 and continued for 7 months. The second series was started in August 1956 and continued for 1 year. In each series, drums and barrels packaged in the normal manner with both liners and sealers were stored in each room to determine their ability to withstand insect invasion. In addition, each possible barrier against insect contamination of the milk itself was evaluated--that is, the container, the kraft sealer, the kraft liner, and the polyethylene liner--by either eliminating the sealer or liners or placing insects outside each of the various barriers or in the milk itself. The value of insecticidal treatments was studied by elimination of the liners, and in some cases by elimination of the sealer as well.

An indication of the proclivity of dermestid beetles to hide in empty drums and packages of liners was obtained by placing several drums and packages in the infested rooms in each series of tests. The inner surface of some empty drums was sprayed with pyrethrum to investigate its possible effect on insect harborage.

In the first series, each room was initially infested with 1,200 larvae of the test insect. These were scattered on the floor with quantities of nonfat dry milk to serve as a possible food supply and to encourage natural infestation. Later, the milk was removed in an effort to induce the insects to seek food in the test containers. During this experiment the infestation was supplemented by introduction of 1,200 adults and 4,100 larvae of the larger cabinet beetle and 290 adults and 2,000 larvae of the black carpet beetle.

In the second series, the original infestation consisted of 1,200 adults and 2,000 larvae of the larger cabinet beetle and 75 adults and 1,200 larvae of the black carpet beetle. No nonfat dry milk was scattered on the floor until the test had been in progress

2 months. The initial infestations were supplemented during the storage period by 2,435 adults and 4,260 larvae of the larger cabinet beetle and 1,800 adults and 600 larvae of the black carpet beetle. The outline of each series of tests is given in table 1.

The number of insects observed on the exterior of each container was recorded weekly. At the conclusion of the 7- and 12-month storage periods, all containers were critically examined, and the number of dead and live larvae, pupae, adults, and cast skins were recorded according to location. The milk in each container was then sifted through 40- and 60-mesh screens in sequence in a laboratory-type mechanical sifter, and separate records were kept of the insect and cast skins recovered from the top 3 inches and from the remainder of the milk. The empty drums and packaged liners were also examined at the time.

In each of the tests in which the resistance of the liner to penetration was studied by placing insects in the dry milk, between the liners, or between the outer liner and the container, 50 larvae were used. In the first series, 1 lot of 50 additional larvae of the larger cabinet beetle was placed in the infested milk during storage, 3 lots each between the liners, and 2 lots each between the outer liner and the container.

RESULTS

Results of the 2 series of tests are given in tables 2 and 3. No insects reached the commodity in drums or barrels packed according to present commercial practice (table 2, tests 1 and 2; table 3, test 1). In the first series of tests no larger cabinet beetles entered the drums, but in the second series, live larvae were found between the kraft sealer and the lid of 2 drums and between the kraft liner and container wall of 1 drum. No evidence of insect invasion in drums by the black carpet beetle was noted in either test.

The barrels were not as resistant to invasion as the drums. In table 2, test 2, it will be noted that both species were found between the container wall and the kraft liner and between the liners. This occurred in all replications in the room infested with the larger cabinet beetle and in 2 of the 3 replications in the room infested with the black carpet beetle.

Effectiveness of the drums alone in preventing invasion is further delimited in test 3, tables 2 and 3. No black carpet beetles invaded any drums packaged without liners or sealers, but larvae of the larger cabinet beetle invaded 7 of the 14 drums. In 4 of the drums the larvae were recovered from the milk itself.

The importance of the use and proper alignment of the circular kraft sealer placed over the open end of the drum prior to placement of the metal lid is well illustrated in tests 1 and 3, table 2. No larger cabinet beetle larvae were noted in any drum packed with a sealer whereas live insects were noted in the milk in all drums packed without them. In table 3, tests 1, 2, and 3, the importance of the sealer is not as vividly illustrated. However, cast skins or larvae were found inside all untreated drums stored without liners or sealers in the room infested with the larger cabinet beetle, while only 1 of the drums with sealers was invaded.

The kraft paper liner was readily penetrated by both species (tests 2, 5, 6, and 7, table 2, and 4, 5, 6, and 7, table 3). The polyethylene liner was also penetrated by both species, but less readily by the larger cabinet beetle (tests 5, 6, and 7, table 2, and 4, 5, 6, and 7, table 3).

Test 8, table 2 and test 7, table 3 were set up in the belief that insect contamination of milk may occur through the polyethylene tie. However, no evidence was noted during either of the tests that such was the case, and double tying does not appear necessary.

Insecticidal sprays applied to the exterior of drums did not prevent invasion by the larger cabinet beetle in tests 8 and 10, table 3. However, when the sealer was sprayed with malathion, no insect succeeded in invading the drums.

Very few insects were observed on the exterior of the containers during the weekly observations, and no particular location pattern was noted. However, the periods of observation represented only a small fraction of the total elapsed time covered by the test. Therefore, the extent to which the insects moved about over the containers may have been considerably more than these observations indicated. On the other hand, an attempt was made to duplicate actual storage conditions as closely as possible, with the exception of the unusually large number of insects introduced. This may indicate that these insects do not crawl onto the containers very much in commercial storage either.

Very few insects sought harborage in the empty drums and packages of kraft liners. Only 1 live larva, 1 dead adult, and 1 cast skin of the larger cabinet beetle were recovered in drums in the tests. No black carpet beetles were found in any drum during the second series of tests, but in the first series, 2 larvae were found in the rim, 2 more within a drum, and 14 beneath the kraft paper liner on the bottom of 1 drum. No adults or larvae of either species were found on or in any polyethylene liners stored in either room. One to two live larvae were found inside 2 of the kraft liners stored in the room infested with the black carpet beetle, and from 3 to 5 on the exterior of the remaining liners. An adult was found in only 1 liner. One to two larvae were found on the exterior of 3 kraft liners and 2 larvae in the interior of 1 kraft liner stored in the room infested with larger cabinet beetles.

DISCUSSION

These tests demonstrated that dermestid beetles could invade either drums or barrels, both with and without sealers, and penetrate both the kraft and polyethylene liners, but that the insects did not pass this combination of barriers and infest the nonfat dry milk. The exposure to insect infestation in these tests was more severe than would be encountered under normal storage conditions. The drum, sealer, and polyethylene liner offered considerable resistance to invasion by the larger cabinet beetle even under these severe exposure conditions. The sealer and liner, however, appeared to be readily penetrated by the black carpet beetle. A malathion spray may be useful as an additional barrier, but it would have to be used in a manner that would not result in contamination of the commodity.

Adult emergence among both species was minimal, and little if any evidence of reproduction occurred in any preinfested drums. This would indicate, along with laboratory studies, that dry milk is not a favorable food for dermestids.

It is concluded, therefore, that the standard method of packing nonfat dry milk in drums containing a kraft sealer, a kraft outer liner, and a polyethylene inner liner presents a package highly resistant to invasion by the larger cabinet beetle and the black carpet beetle during storage. Infestations that have been found in stored dry milk so packed probably originated before or at the time the commodity was packed. Producers should, therefore, concentrate on improvement of plant sanitation procedures, on possible modifications of plant equipment and construction, and on methods to insure a stock of empty drums, liners, and sealers free from insects.

Table 1.--Number of containers used in tests evaluating the resistance of drums and barrels of nonfat dry milk to insect invasion, by type of test, packaging method, and kind of beetle

Type and number of test, method of packaging, and insecticidal treatment	First series				Second series	
	Larger cabinet beetle		Black carpet beetle		Larger cabinet beetle	Black carpet beetle
	Drums	Barrels	Drums	Barrels	Drums	Drums
	Number	Number	Number	Number	Number	Number
Exposure of standard industry pack:						
1. Kraft (outer) and polyethylene (inner) liners and kraft sealer	3	3	3	3	8	8
Evaluation of barriers:						
2. Container without liners	--	3	--	3	4	4
3. Container without liners or sealers	3	--	3	--	4	4
4. Standard pack, insects placed in milk	3	--	3	--	4	2
5. Standard pack, insects placed between liners	3	--	3	--	4	--
6. Standard pack, insects placed between container and outer liner	3	--	3	--	4	--
7. Standard pack, polyethylene liner double tied	3	--	3	--	--	--
8. Standard pack, polyethylene liner double tied, insects placed between liners	--	--	--	--	4	--
Evaluation of insecticidal treatments:						
9. Container without liners or sealers, exterior sprayed with pyrethrins	--	--	--	--	2	2
10. Container without liners, sealer sprayed with pyrethrins	--	--	--	--	2	2
11. Container without liners or sealer, exterior sprayed with malathion	--	--	--	--	2	2
12. Container without liners, sealer sprayed with malathion	--	--	--	--	2	2
Harborage in empty drums:						
13. Empty containers	3	--	3	--	4	4
14. Empty containers, interior sprayed with pyrethrins	--	--	--	--	4	4
Total	21	6	21	6	44	30

Table 2.--Number and location of insects and cast skins in containers of nonfat dry milk and number of liner penetrations, by kind of beetle, at conclusion of the first series of tests

Type and number of test and method of packaging	Between wall and outer liner				Between liners			
	Larger cabinet beetle		Black carpet beetle		Larger cabinet beetle		Black carpet beetle	
	Insects	Cast skins	Insects	Cast skins	Insects	Cast skins	Insects	Cast skins
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Exposure of standard industry pack:								
1. Drums with liners and sealer	0	0	0	0	0	0	0	0
2. Barrels with liners and sealer	42	6	44	4	31	21	5	5
Evaluation of barriers:								
3. Drums without liners or sealer	--	--	--	--	--	--	--	--
4. Barrels without liners	--	--	--	--	--	--	--	--
5. Standard pack drums, insects placed in milk	0	0	0	0	1	1	50	0
6. Standard pack drums, insects placed between liners	20	4	34	8	246	344	50	4
7. Standard pack drums, insects placed between container and outer liner	96	109	59	53	27	23	15	2
8. Standard pack drums, polyethylene liner double tied	0	0	0	0	0	0	0	0

Type and number of test and method of packaging	In milk				Penetration of liners			
	Larger cabinet beetle		Black carpet beetle		Kraft		Polyethylene	
	Insects	Cast skins	Insects	Cast skins	Larger cabinet beetle	Black carpet beetle	Larger cabinet beetle	Black carpet beetle
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Exposure of standard industry pack:								
1. Drums with liners and sealer	0	0	0	0	0	0	0	0
2. Barrels with liners and sealer	0	0	0	0	10	0	0	0
Evaluation of barriers:								
3. Drums without liners or sealer	15	21	0	0	--	--	--	--
4. Barrels without liners	42	145	21	0	--	--	--	--
5. Standard pack drums, insects placed in milk	96	331	68	10	0	30	1	139
6. Standard pack drums, insects placed between liners	6	3	15	102	6	46	1	80
7. Standard pack drums, insects placed between container and outer liner	2	2	0	0	31	102	1	0
8. Standard pack drums, polyethylene liner double tied	0	0	0	0	0	0	0	0

Table 3.--Number and location of insects and cast skins in the containers and the number of liner penetrations at the conclusion of the second series of tests

Type and number of test	Between wall and outer liner				Between liners			
	Larger cabinet beetle		Black carpet beetle		Larger cabinet beetle		Black carpet beetle	
	Insects	Cast skins	Insects	Cast skins	Insects	Cast skins	Insects	Cast skins
	Number	Number	Number	Number	Number	Number	Number	Number
Exposure of standard industry pack:								
1. Drums with liners and sealer	4	3	0	0	0	0	0	0
Evaluation of barriers:								
2. Drums without liners	--	--	--	--	--	--	--	--
3. Drums without liners or sealer	--	--	--	--	--	--	--	--
4. Standard pack drums, insects placed in milk	2	5	12	0	5	13	33	17
5. Standard pack drums, insects placed between liners	10	32	--	--	101	181	--	--
6. Standard pack drums, insects placed between container and outer liner	25	179	--	--	23	79	--	--
7. Standard pack drums with polyethylene liners double tied, insects placed between liners	6	56	--	--	46	172	--	--
Evaluation of insecticidal treatments:								
8. Drums without liners or sealer, exterior sprayed with pyrethrins	--	--	--	--	--	--	--	--
9. Drums without liners, sealer sprayed with pyrethrins	--	--	--	--	--	--	--	--
10. Drums without liners or sealers, exterior sprayed with malathion	--	--	--	--	--	--	--	--
11. Drums without liners, sealer sprayed with malathion	--	--	--	--	--	--	--	--

Type and number of test	In milk				Penetration of liners			
	Larger cabinet beetle		Black carpet beetle		Kraft		Polyethylene	
	Insects	Cast skins	Insects	Cast skins	Larger cabinet beetle	Black carpet beetle	Larger cabinet beetle	Black carpet beetle
	Number	Number	Number	Number	Number	Number	Number	Number
Exposure of standard industry pack:								
1. Drums with liners and sealer	0	0	0	0	0	0	0	0
Evaluation of barriers:								
2. Drums without liners	16	9	[1] 2	0	--	--	--	--
3. Drums without liners or sealer	10	10	[1] 1	[1] 2	--	--	--	--
4. Standard pack drums, insects placed in milk	118	458	28	37	3	12	5	48
5. Standard pack drums, insects placed between liners	15	0	--	--	27	--	2	--
6. Standard pack drums, insects placed between container and outer liner	5	8	--	--	[3] 36	--	3	--
7. Standard pack drums with polyethylene liners double tied, insects placed between liners	18	87	--	--	[4] 23	--	6	--
Evaluation of insecticidal treatments:								
8. Drums without liners or sealer, exterior sprayed with pyrethrins	4	0	0	0	--	--	--	--
9. Drums without liners, sealer sprayed with pyrethrins	9	6	0	0	--	--	--	--
10. Drums without liners or sealers, exterior sprayed with malathion	[2] 12	14	0	0	--	--	--	--
11. Drums without liners, sealer sprayed with malathion	0	0	0	0	--	--	--	--

[1] The partition between the exposure rooms was not entirely insect-proof and a few larger cabinet beetles migrated into the black carpet beetle room and vice versa. [2] Anthrenus larvae; part of an infestation present in limited numbers at all times in warehouse in which infestation rooms are located. [3] 21 penetrations in kraft sealer. [4] 2 penetrations in kraft sealer.

Marzke, Frederick O

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